VULCAN PROCESS

INSTRUCTIONS

ON

OXYACETYLENE WELDING

AND CUTTING

INSTRUCTIONS

ON

WELDING and CUTTING of METALS

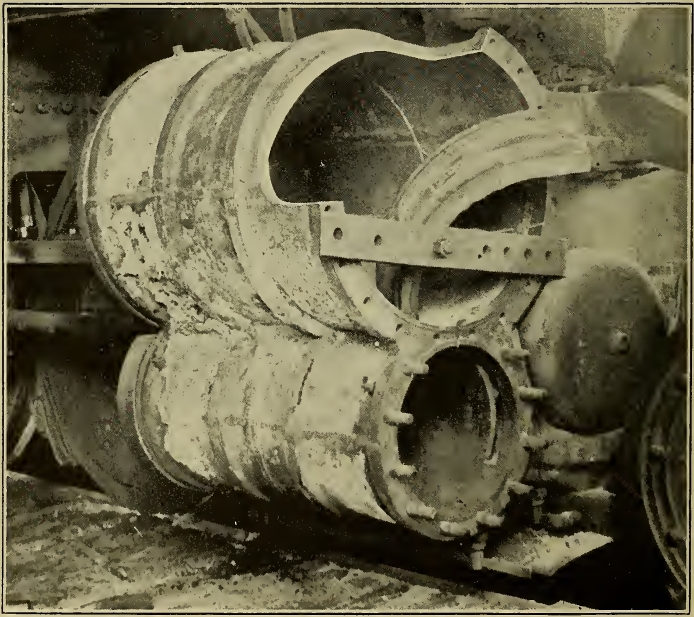
Oxyacetylene Process

VULCAN PROCESS CO.

Minneapolis, Minn. Cincinatti, Ohio

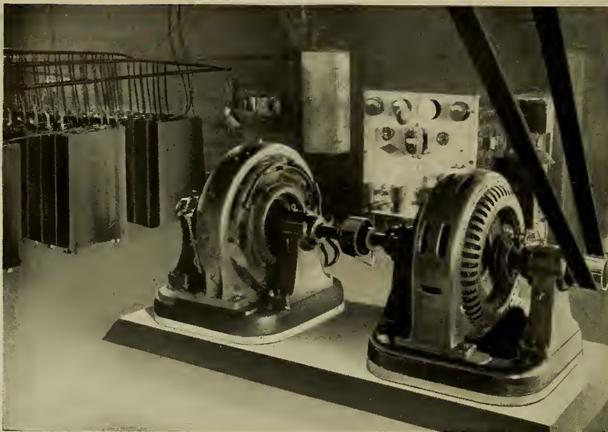
"A Vulcan weld has always held"

CONTENTS



Broken and Useless.

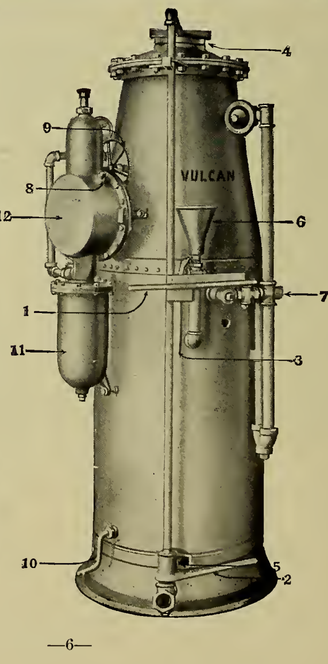
Welded and Good as New.

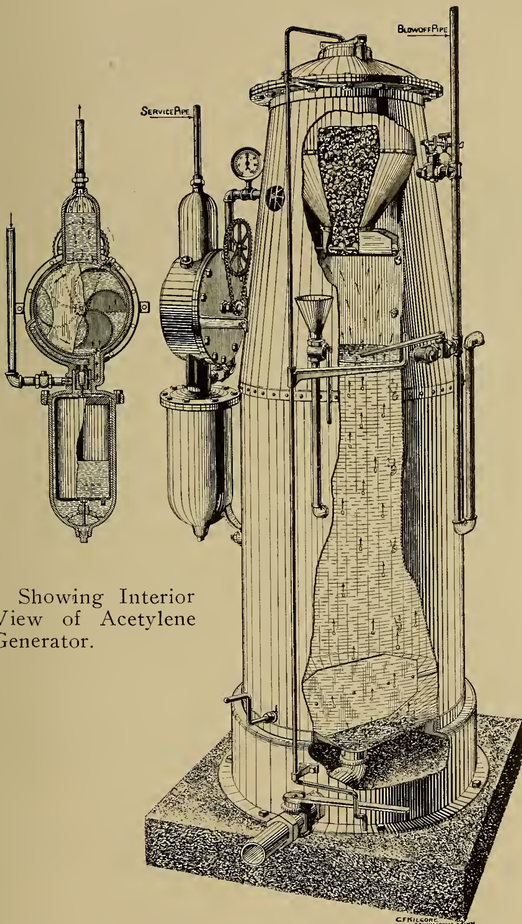


View of a corner of one of our 100 cell oxygen and hydrogen generating plants, making 7500 to 10,000 feet of oxygen gas and 15,000 to 20,000 feet of hydrogen gas, of over 99 per cent purity per day, also showing 150 h. p. motor generating plant.

Greatest success in welding is attained by using absolutely pure oxygen in blow torch. Cuts illustrate plants making these gases.

Cut of our approved automatic acetylene generator which makes gas from carbide at about ¾c per ft. when carbide is $3.75 per 100 lbs.



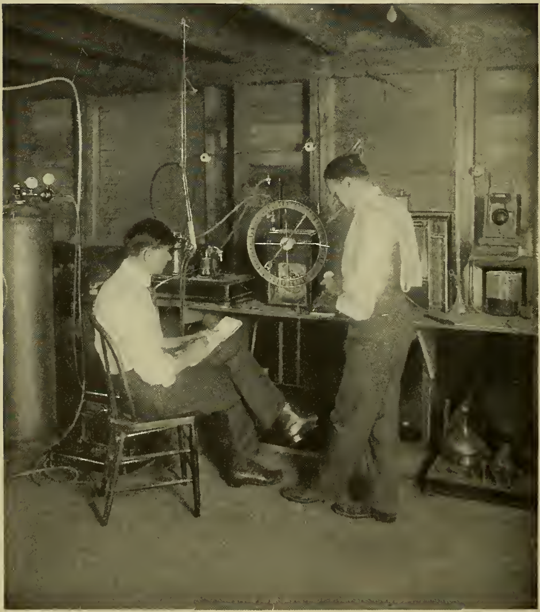


Showing Interior View of Acetylene Generator.

CHAPTER I.

HISTORY.

The powers used in welding are not by any means new, but the application of these forces in new and unusual ways, particularly in Autogenous

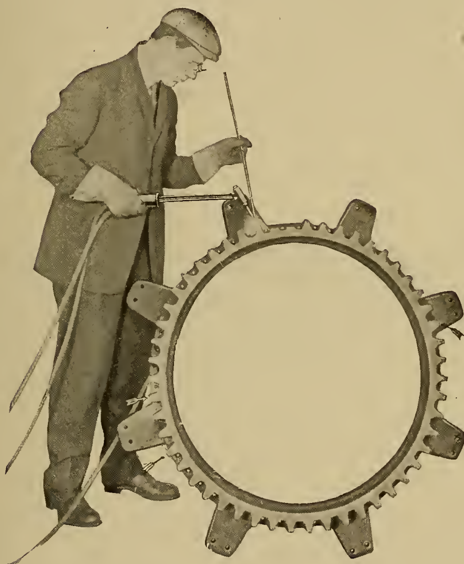


A Corner in our Laboratory.

Welding, is comparatively new to the commercial world and a brief outline of development is profitable reading.

It is said that old Ninevah was illuminated with

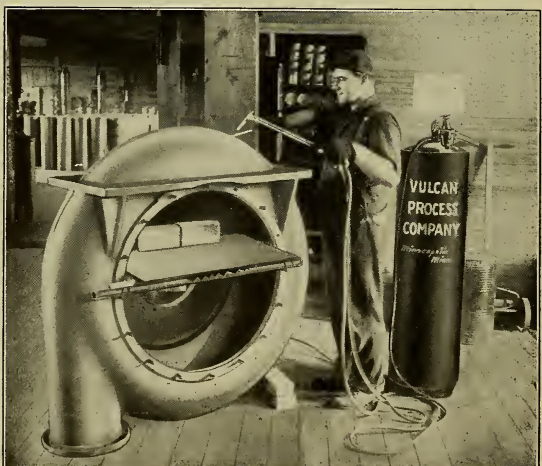
artificial lights so brilliant that at times it was difficult to distinguish night from day. This announcement may be somewhat exaggerated but only illustrates that the ancients had many secrets in the arts of various kinds, and particularly in the metal



Welding in Gear Teeth in Gas Tractor Wheel.

world, that the moderns have as yet not achieved. The Damascus sword and special treatment of copper are illustrations of this kind; and yet so extensive is the scientific knowledge in the laboratory today that it would seem as if there are no

secrets which are beyond the ken of the skilled chemist and his co-laborers who place before the commercial world the knowledge and skill of the field of research in this vast domain. Among the various scientific lines of work one of the interesting groups to see considerable change and development is the gas realm. In 1792 William Murdock, an Englishman, lighted his workshop with gas obtained from soft coal; ten years later extensive gas works were established at Birmingham, England. 1803 saw the Lyceum Theatre, London, lighted with gas and in 1810 a powerful Company was formed to overcome the prejudice of the people of London.



Showing Centrifugal Pump with 1½ ft. crack and patch 6x9 in. successfully welded.

Oil gas and water gases have had to force their way into popular approval; while last but by no means least, acetylene gas as recent as 1892 was discovered by accident by Thomas L. Wilson at Spray, North Carolina and was found developed in a semi-calcium carbide formation in quantity large enough for commercial purposes, and Lord Kelvin this same year gives Mr. Wilson credit for this advance to science and commerce.

Bosh Jacket Welded in Boiler Shop at Duluth, Minn.

Extract of J. E. Johnson's letter of Feb. 11, 1913, relative to this work.

"Roughly, the jacket is a truncated cone, eleven feet in diameter at the bottom and about sixteen feet in diameter at the top, by about nine feet high. Both top and bottom were flanged out horizontally to a distance of about three inches. The thickness of the metal is ½ inch throughout.

The jacket was made up in four sections, which were welded together along the vertical joint. What we particularly desired was to get, first a smooth

job, and second, only one thickness of metal. The first so that the cooling water would stay on the jacket better than it is possible for a film of water to do on such a surface when broken by seams and rivets, even though the latter be countersunk. The second latter to eliminate the greater liability to burning, due to double thickness of metal.

We regard the construction as an eminently satisfactory one in both particulars. By chippings the exterior of the seam with a broad chisel and then grinding it we get a job as smooth as the rest of the sheet, and it is impossible to see without great difficulty where the joints are.

The jacket has given us a minimum of trouble and if we are going to install another one, I should not hesitate to have it welded in the same way."

Yours truly,

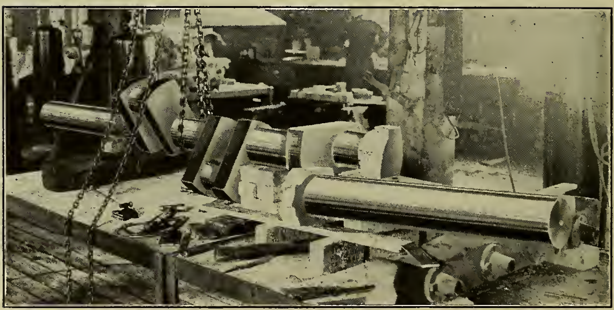
J. E. Johnson, Jr., Manager.

Mr. Johnson is well known on iron ranges and in the metal world.

CHAPTER II.

CALCIUM CARBIDE

from which is produced acetylene gas is a hard opaque, crystalline substance, known to the chemist as CaC^2, merely an expression for one unit of mass of calcium, the metal which exists in lime, combined with two mass units of carbon. Calcium carbide is a compound which contains calcium and carbon only. The calcium in it is about 62½ per cent and the carbon is 37½ per cent of the weight



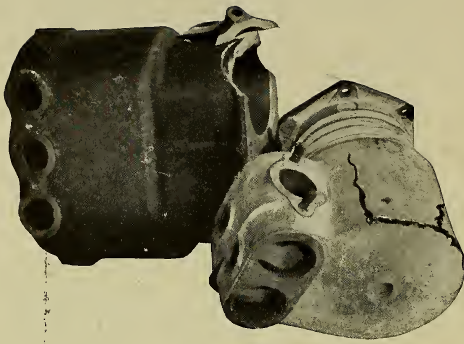
CRANK SHAFT BROKEN.
6 in. crank shaft 11 feet in length, used in producer gas engine; successfully welded in our repair department.

of the carbide. Calcium, a metal, and carbon, a substance like coal, are both contained in this material, calcium carbide, though the compound is so different from either constituent.

Calcium carbide is generally of a dark brown or black color, sometimes described as dark gray, and sometimes as a bluish black, and often possessing a reddish tinge. If broken while hot, the fracture exhibits considerable iridescence. It is

SAME CRANK SHAFT WELDED.
Good as new and working every day.

brittle, and is more or less crystalline in structure. Its specific gravity is 2.22 to 2.26; it endures heating to redness without melting or suffering other change, though it softens and fuses under electric



Cylinder Broken and Useless.

Welded and Good as New.

heat; it will not burn, except when highly heated in oxygen; it looks like a mass of stone. A cubic foot of the crushed material weighs one hundred and thirty-six pounds and in weight, color and many physical characteristics it is frequently compared with granite.

Calcium carbide may be preserved any length of time if kept sealed from air, but the ordinary moisture of the atmosphere gradually slakes it and it becomes changed on long standing, into slaked lime. This slaking power gives it a name, which is sometimes heard: Acetylene Lime. It always possesses a penetrating odor, which, however, is not due to the carbide itself, but to the fact that it is constantly affected by moisture, yielding minute quantities of acetylene, which accounts for the odor rather than the carbide itself. It is not affected by solvents, such as carbon bi-sulphide, petroleum, chloroform, ether or benzol, but if allowed to come into contact with water, or any mixture containing water, an immediate and vigorous decomposition takes place, evolving liberal quantities of gas; it is unaffected by shock, concussion or age.

Carbide is a safe substance to store or transport under proper conditions. Transportation lines accord it the same classification rates as various other forms of hardware. It cannot explode, take fire, or otherwise do harm, being similar to lime in this respect also. Since even the slow action of moisture ordinarily present in the air will in time render carbide entirely useless, it becomes absolutely necessary, in order to securely preserve it, to pack it in perfectly tight, closely sealed containers, generally drums or cans. Granted protection from water, no substance can be safer or less likely to cause

trouble when stored or conveyed from place to place. Lime becomes very hot when acted upon by water; also so does carbide, and the only essential difference is that carbide, when it slakes with water, yields a combustible gas. Carbide decomposes with water in accordance with the following chemical equation.

$$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$$

Carbide and water yield slake lime and acetylene.

An easy calculation shows that sixty-four unit-weights of carbide require thirty-six of water, producing also seventy-four unit weights of slaked lime and twenty-six of gas. A pound of absolutely pure carbide yields five and one-half cubic feet of acetylene. Yet, absolute chemical purity is not a practical commercial possibility, and it is natural to suppose that commercial products of different manufacturers will vary in purity. Calcium carbide is no exception. In practice, good carbide may generally be expected to produce never less than four and a half cubic feet, measured at ordinary temperature, and rarely more than five and one-fourth cubic feet per pound of carbide. It may be ordinarily calculated at five. It is important to remember that the exact proportional weights of water and carbide must always enter into combination, i. e., sixty-four of actual carbide to thirty-four of water, be it in ounces, pounds or tons; also that the same proportional weight of acetylene must always result. Any apparent exception can only be due to impure carbide, loss of gas, or failure to secure complete consumption of material.

The evolved gas does not take fire of itself but is easily lighted. The gas burns with a bright light, not brilliant, for it needs control to bring out this

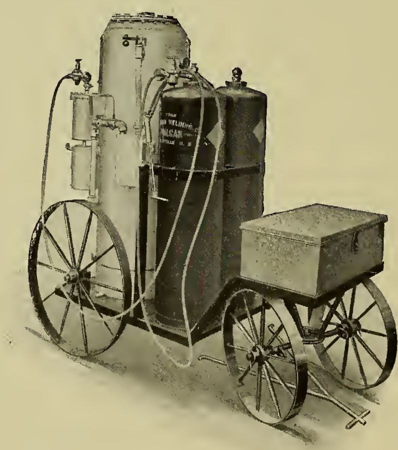
property, and much smoke. In fact, soot in solid flakes may be seen floating through the air when the experiment is performed in this rough way. Carbide is not inflammable, nor possessed of any explosive property such as is sometimes erroneously attributed to it.

When water is sprinkled or sprayed upon carbide, in not excessive quantities, the resultant slaked lime is left in a perfectly dry and dusty condition, occupying considerable more space than the original carbide. When more than enough water is employed, the residuum will, of course, be wet, either pasty, or thinner if a large excess of water is employed.

CHAPTER III.

ACETYLENE GAS.

Acetylene gas is commonly made by bringing together calcium carbide and water. The chemical reaction is $CaC^2+H^2O=C^2O+CaO$. When acetylene is generated by this method a considerable amount of heat is liberated. To overcome this a large excess of water should be employed, and the carbide should be dropped into the water. The car-



Illustrating portable plants with Vulcan Acetylene Generator, also plant Nos. 3 or 4 when mounted on truck.

bide sinks to the bottom of the generator and the gas, upon being generated, rises to the top of the generator. As it passes upward through the water it is washed free from dust particles, and at the same time is cooled. Acetylene can also be prepared by dropping water upon the carbide. When this is done there is no provision for the absorption of the heat of chemical action. The gas, when thus rapidly generated, becomes hot and full of fine dust, making it objectionable for welding purposes. The way to avoid this is to generate the gas by what is termed a "carbide feed" generator; that is, by dropping the lumps of carbide into the water. At least one gallon of water to every pound of carbide should be provided. A cut of one of the simplest generators is shown in Figure 1. This generator is manufactured by the Northern Welding Company for the Vulcan Process Co. of Minneapolis and Cincinnati, and not operated by the usual clockworks, regulating diaphragms, weights, etc. The pressure is regulated by means of a patented by-pass arrangement, and the pressure does not vary perceptibly. By means of a simple device the pressure can be set at any desired pressure, and this pressure will then be maintained until all of the carbide has been used up.

The different manufacturers usually furnish complete instructions for operating their own makes of acetylene generators, and these instructions should be followed as closely as conditions will permit. Compressed dissolved acetylene can be obtained from one of the companies engaged in this business. Cylinders containing from 40 to 500 cubic feet of dissolved acetylene can be purchased. The

large cylinders, however, are quite heavy, weighing as much as 435 pounds.

The following is a summary of the different types of acetylene generators, and their advantages and disadvantages:

Drip Type Generators.

1. Over-heating.
2. After-generation.
3. Incomplete decomposition of carbide.

Flooding Type Generator.

1. Over-heating.
2. After-generation.
3. Extra gasometer necessary to avoid undue pressure in generator.

Dipping Type Generator.

1. Excessive over-heating, hence dangerous.
2. After-generation present.

Carbide-to-Water Type Generator.

1. Over-heating impossible if water is in excess.
2. After-generation impossible.
3. Lack of over-heating causes pure gas to be evolved.
4. Dust is washed out of gas, as gas bubbles up through water.

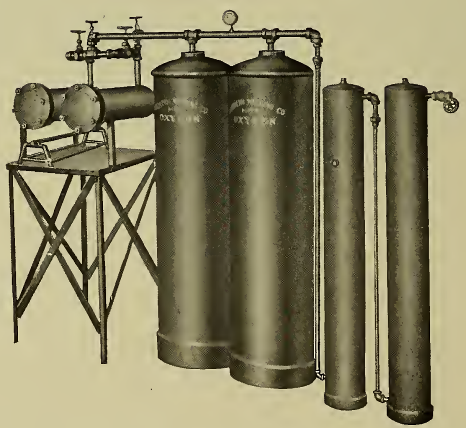
Showing oxygen cell plant making 99% purity oxygen from water by electrolysis.

CHAPTER IV.

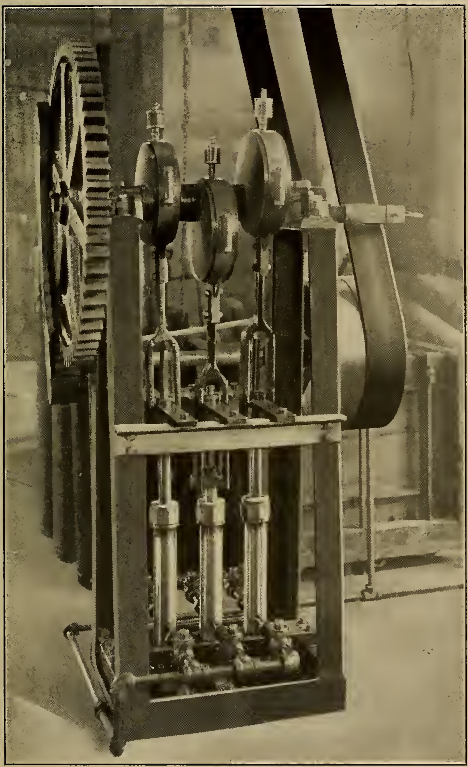
OXYGEN GAS

is the most widely distributed of all the elements, and was isolated first by Joseph Priestly in 1774, the following year Lavoisier gave the opinion that this substance was same as in air and gave it the name of oxygen. It is heavier than air in the proportion of 1 to 1.056. It was liquified for the first time in 1877. For general commercial purposes it can be made from chlorate of potash (crystals) with best quality manganese dioxide in the proportions of 100 pounds of the chlorate of crystal potash to

13 pounds of the manganese dioxide. (Note weight, not volume.) These two chemicals are first thoroughly mixed and then placed in a retort made for that purpose, and external heat applied. This liberates the oxygen, which passes off through washers and into the pressure tanks direct or into a gasometer. If first run into a gasometer it is piped from there, and by means of a specially constructed oxygen compressor is compressed into pressure tanks. The cost of producing chemical oxygen, of course, depends largely upon the price of the chemicals. The usual market price, in quantity, of chlorate of potash crystals, is 9½c per pound. The best



Cut showing chemical oxygen plant, which we do not recommend only in emergency cases as the gas is not as pure. 1 foot of Electrolytic oxygen gas goes as far as 2 feet of Chemical gas in cutting and same pro rata in welding.

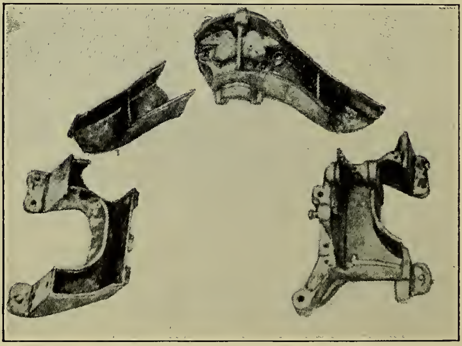


Showing Hydraulic 3 cylinder pump, capacity 12 cub. ft. per minute, compressing oxygen gas from 1500 to 2200 lbs. pressure.

The most simple and satisfactory pump for plants up to 10,000 ft. of gas per day.

grade of manganese dioxide, 2¾c. To this should be added freight and cartage. Including the cost of manufacture, and figuring the cost of chemicals, as above stated, the oxygen would cost approximately 3c per cubic foot.

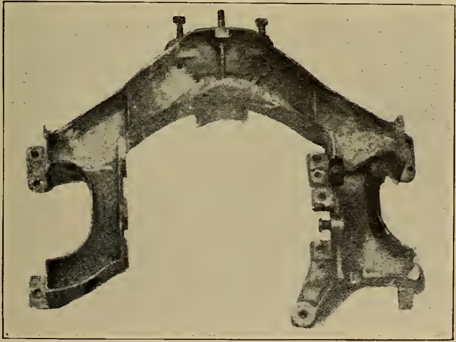
The greatest precaution must be used in preventing the smallest portion of carbon, such as in paper, small pieces of wood, grease, or any other inflammable material, becoming mixed with the compound, as if such should be accidentally placed in the retorts with the chlorate of potash, an inflammable gas would be created when the retort is heated, and this might cause an explosion. For this reason the manganese dioxide should be of the best quality, and it should be screened through a fine sieve before mixing with the potash, and no opportunity should be permitted for the admission of any such inflammable materials after it has been screened.



Aluminum Frame Broken.

In the manufacture of chemical oxygen it should be passed through a chemical solution to purify it of the chlorine gas. The formula for this solution is furnished by the manufacturers of chemical oxygen plants.

Some companies manufacture oxygen for commercial purposes from the air. This entails a large investment, and such an equipment cannot be installed by the ordinary user of oxygen. The oxygen made from the air can be used for welding, although, on account of the nitrogen it contains, it is not nearly as satisfactory as the pure oxygen made by the electrolysis of water. The latter method produces the purest oxygen, which is far superior for both welding and cutting. It is practically 100% pure, and is used for medicinal purposes, as well as for welding. The writer strongly recommends the electrolytic oxygen where it can be procured in pressure cylinders at a cost of 3½c per cubic foot or less.



Same frame welded good as new.

CHAPTER V.

HYDROGEN GAS.

Water when decomposed by process of electrolysis produces two gases, the volumetric proportion being Hydrogen in two parts and Oxygen one part. Hydrogen is also found in considerable quantity in animal and vegetable matter, is the lightest of all gases, air weighing 14½ times this gas. This gas is highly inflammable and is of considerable use when united with oxygen in metal cutting. Its heat however is about 4100° Fhr., while that of oxy-acetylene is approximately 6300° Fhr. In cutting steel it leaves a comparatively smooth wall with the metal but little effected by oxidation on either side of the cut. Steel up to 16″ thickness has been successfully cut by these two gases. Thin metals up to 3/16″ thick can also be successfully welded by these two gases, but for rapid and economical welding the oxy-acetylene flame is decidedly its superior.

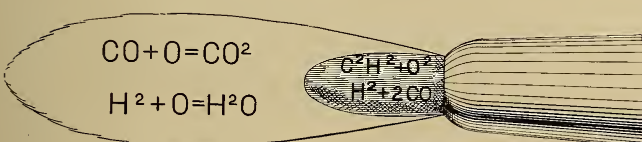
This gas, while a by-product of oxygen from water, is daily increasing in its usefulness. Lead burning, various uses in electric work, heating, laboratory, soap making, vacuum work, balloon filling, gem production, etc., etc., are some of its principle uses.

Illustrating regulation of the flame. Top figure showing excess of oxygen; middle figure showing neutral flame; lower figure showing excess of acetylene.

CHAPTER VI.

USE OF THE OXY-ACETYLENE FLAME.

Almost all metals can be united by autogenous welding which is simply uniting these metals without compression or hammer blows, but by heat



Phases of the combustion in the oxy-acetylene flame.

alone, the metal at point of fusion flowing together and in majority of cases being recast locally with extra metal of same kind being used when necessary.

The manufacturer in almost all lines of metal work is daily finding new adaptations for this great power, while those who repair all kinds of broken metal are daily adding to their knowledge of this art which soon makes them skilled in this profitable

Showing a complete oxy-acetylene plant made in various sizes, all ready for work.

business. It is of considerable value for cutting steel and iron in wrecking buildings, bridges, etc. Every week sees new uses for this great force from nature's laboratory. Chief among ways that apparatus, noted in this book, will be called on for work, will be making good as new, broken parts of autos, traction engines, general machinery (of any size), navy yard and railroad shop work and all kinds of farm implement work.

CHAPTER VII.

VULCAN AUTOMATIC ACETYLENE GENERATOR.

Chapter three outlines the various types of generators that can be used to produce acetylene gas. In reading over the advantages and disadvantages of the different methods of the generation of acetylene it will be noted that the "carbide to water feed" generator has none of the disadvantages of the other types, but does have a great many advantages that are not possessed by the other generators.

Of the two styles of generators, low and medium pressure, the latter is the better for welding as the acetylene, as well as the ovygen, should be delivered to the gas mixing chamber of the welding torch under pressure. Where both gases are thus

combined under a positive, even pressure, their mixture is more complete—assuming that the mixing chamber of the torch is properly constructed. Unless this thorough mixing of the two gases takes place, the result will be incomplete combustion, hence waste of gas and loss in efficiency.

With the low pressure or gasometer type of generator, the injector type of torch is principally used. By this is meant that the oxygen under high pressure, in passing through the mixing chamber of the torch, sucks the acetylene through with it. In this way the two gases are not thoroughly mixed, resulting in waste of gas as well as poor welding. The feeding mechanism of most pressure generators now on the market are operated by means of a complicated clock-work with pulleys and weights, leather diaphragms, etc. These frequently get out of order at just the time when the operator needs the gas the most and the resulting delays are expensive as well as annoying.

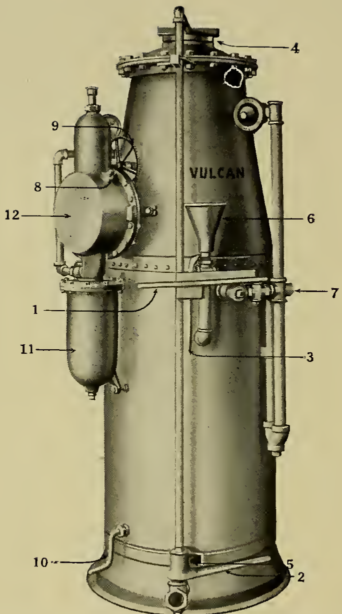
The Vulcan automatic pressure generator operates on an entirely new principle. It is the only approved pressure generator manufactured that operates the feeding mechanism by means of the pressure of the gas. This ingenious device is, of course, fully protected by patents and several leading acetylene generator dealers have adopted the Vulcan generator to the exclusion of the old type.

The plan of this generator is such that the torch demand automatically regulates the making of the gas; that is, as gas is consumed in the torch or torches, as the case may be, gas is made in same proportion in the generator to supply that gas consumption in the torch, the work is simple, positive and accurate, does not vary as in other types of

pressure generators and in a word places this generator in a class by itself. **Remember this generator has a constant feed at a variable speed as contrasted with the ordinary type, constant speed starting and stopping between given limits.** The rate at which the carbide is fed in our generator varies directly with the rate at which the gas is used, in other words no more carbide is ever fed to the generator than is absolutely necessary at that perticular moment. **This means that the heat generated is always and positively at a minimum, because only the minimum amount of carbide needed is fed at any one time.** For the same reason, it means that after generation is eliminated to the greatest possible degree. Due to the unique feed, no carbide can be fed unless the gas is being used through the service pipe. Finally, any accident any leaky valve, a leaky gasket, leaky joint or a leaking blow off makes the generator in-operative.

These are some of the reasons why we know that our generator is not only the safest but also the most economical that has been built, to our knowledge. To make these facts still more clear, we add a description of the generator and its operation.

Acetylene Generator at top of next page when filled with water up to No. 7 and carbide in No. 4 is ready to make gas automatically as demand of welding torch requires gas.



Acetylene Generator And Directions How To Operate.

To fill generator, open vent valve by turning lever No. 1 one-quarter turn. This releases all pressure in generator. Next revolve agitator handle No. 10 and open sludge cock by turning lever 2 one-quarter turn. This also removes the guard over filling cap 4. After the sludge has drained off release latch 5, which permits closing sludge cock without replacing filling cap guard. Now bring

lever 3 to a horizontal position and fill generator with water through funnel 6 until water flows out of pipe 7 of the overflow chamber. Fill carbide hopper with $1\frac{1}{4}$x$\frac{3}{8}$-inch carbide through opening at 4.

Replace in following order: First filling-hole-cap No. 4; lever No. 3; and last, lever No. 1 which locks all parts.

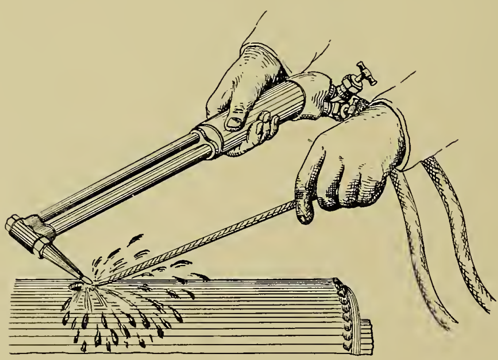
Fill motor case No. 1 and regulator chamber No. 11 with water through filling plug 8. Pipe No. 13 is the blow off, and should be piped without traps to the outside of the building, and with as few elbows as possible, the pipe line terminating in an elbow looking down to prevent the clogging by snow, ice, etc. The pipe 14 is connected to the supply line.

Revolve feed screw sprocket No. 9 until several pounds pressure is shown on indicator. Replace drive chain and the generator is ready for operation. The gas will automatically rise to the proper pressure, the carbide being fed by the power of the gas operating the motor. The regulating device in chamber No. 11 starts and stops the feeding means automatically. **Carbide will positively not be fed into the water unless gas is being used from the supply line.** If the motor continues to revolve after all burners are shut, look for a leak in supply line. Carbide is fed at a rate proportionate to the rate of flow of gas through motor, up to a predetermined volume, which is regulated at the factory to prevent too rapid generation which might be brought about either through ignorance or accident.

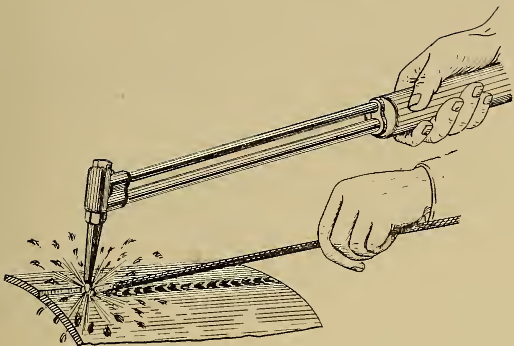
Always keep the motor case filled with water,

for without it the generator will become inoperative.

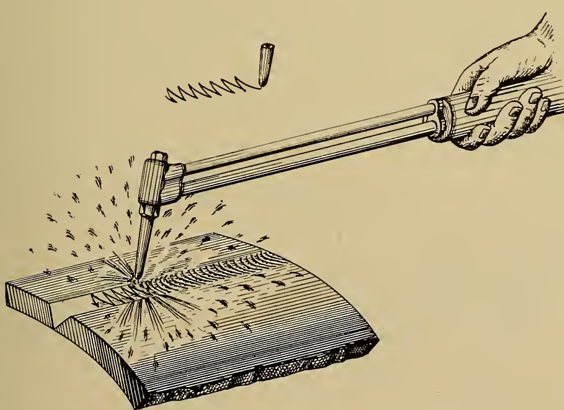
If the pressure in the generator gradually drops, look for a serious leak in the generating chamber in such places as the filling hole cap, etc., since the ratio between the motor and the feed screw is such that when all the gas passes through the motor just enough carbide is fed to keep up the proper pressure, and if part of the gas generated escapes before entering the motor case it does not furnish power to feed carbide, which is necessary to generate gas to take its place. To make this more clear, four cubic feet of gas must pass through the motor to feed one pound of carbide, and if two cubic feet escape before passing through the motor only one-half a pound of carbide will be fed, hence the gradual drop in pressure.



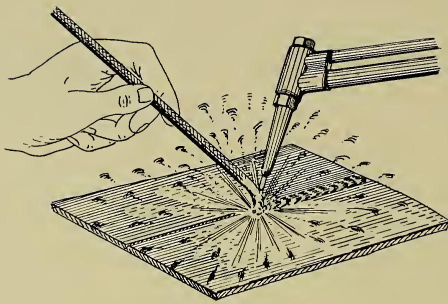
The proper position of welding torch for filling in of holes.



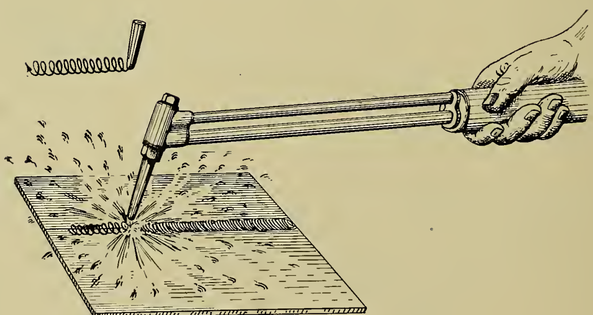
Proper method of holding welding rod.



Circular movement of the welding torch during the execution of the weld.



The metal added must not fall, drop by drop, into the weld.

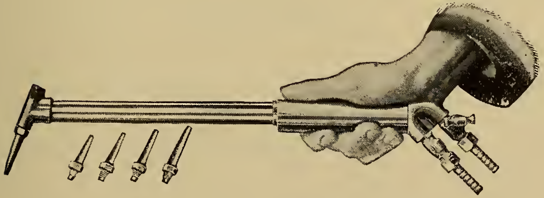


Side to side movement for the execution of welds of greater thickness.

CHAPTER VIII.

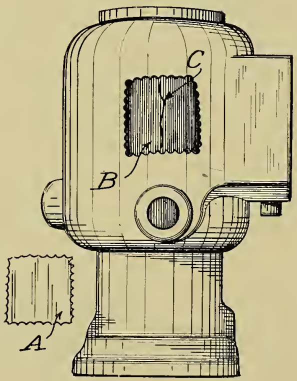
WELDING AND CUTTING TORCHES AND THEIR REGULATIONS.

Generally speaking, there are two types of welding torches, the one being known as the low pressure type, and the other as the high pressure torch. The principle of the low pressure torch is based on that of the injector, the acetylene, which is under pressure of only a few ounces per square inch, being drawn by suction produced by the flow of oxygen. The mixture then passes out of the tip. If the flow of the oxygen should vary, the proportion of the acetylene would not be constant, and any variation in either direction will produce either an oxidizing or carbonizing flame. The low pressure torch has now been largely superseded by the high pressure torch, both in Europe and in this country. In the high pressure torch both the acetylene and oxygen are under an appreciable pressure, which results in a positive mixture under all conditions. The pressure of each gas is kept constant, as required by adjustable reducing valves. The tips can



be detached, and several of different capacity are supplied with each torch, which allows a considerable range of work to be carried on without changing torches.

The writer can highly recommend the "Vulcan" torch or blowpipe. It is much more economical in the consumption of oxygen and acetylene than any other torch now offered to the trade, and is so easily adjusted that there is little or no danger of burning or carbonizing the metal, as is the case with most of the other makes of torches. The reason for this is the ingenious arrangement for the perfect mixture of the two gases before entering the welding tip. This is of the utmost importance, as when there is an excess of oxygen



To weld interior surface of a motor cylinder cut out patch "A" weld crack "C" then weld patch "A" in space "B."

the flame will oxidize or "burn" the metal, and when there is an excess of acetylene the flame carbonizes the metal.

A great many torches "flash back," or burn in the torch tip or head whenever the tip comes in contact with the metal. This defect, as every welder knows, is common in practically every type of

Cutting torch which cuts steel 2″ thick x 1 ft. wide in 1 minute; or cuts a battleship slab of steel 4 ft. x 4″ in 7 minutes.

torch, except the "Vulcan" type above referred to. Dissolved acetylene can also be used with this torch.

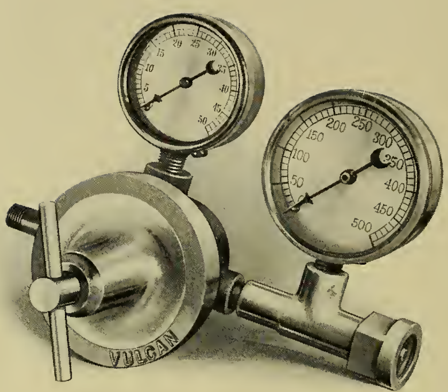
We submit our outline of operation for our cutting torch; the acetylene hose is connected on in the same way as when getting it ready for welding. The oxygen hose is put on the upper connection, only two hoses are required in cutting, the oxygen pressure is regulated to from 25 lbs. to 55 lbs., depending on the thickness of the material to be cut.

The oxygen for use in the pre-heating flame is regulated with the little needle valve. 75 lbs. pressure is too much to operate the preheating flame, and the needle valve is used to cut down the flow of gas that goes through the pre-heating flame. The preheating flame should be regulated to about the same general appearance as the welding flame, that is, a short blue innercone in a long light blue outer flame. The cutting tip should be held about ⅛ to ¼ inch away from the metal to be cut and when the metal is at a melting heat, the lever valve is pressed which starts the jet of oxygen through the cutting tip. All kinds of steel and wrought iron will be readily cut if directions are carefully followed. Do not hold the torch too close to the metal, nor yet too far from it; if the torch is held too close the chances are that the torch will flare out; if it is held too far from the metal the cut will be too wide and ragged; in order to get a smooth straight cut hold the torch close to the metal and move it at an even rate across the feed, from side to side as tipping it one way to the other produces a ragged uneven cut. In order to start in the center of the metal it is necessary to heat a spot to redness, then turn on the oxygen jet slowly until the cutting action is started, gradually increasing the flow of gas and also drawing back the torch head away from the metal several inches so that the metal does not fly back and block up the flow of gas. After the first hole is punctured the torch may be held down close to the metal again and the cutting continued.

CHAPTER IX.

REGULATORS AND INDICATORS.

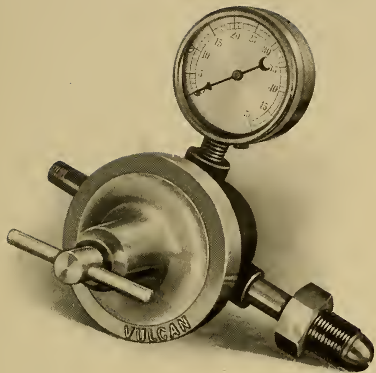
On each piece of mechanism necessary to complete an oxy-acetylene welding plant, depends a certain amount of responsibility, and the automatic oxygen and acetylene regulator is no exception to the rule, for the duty of these regulators is to reduce the gas pressure from 1800 lbs. more or less, to as low as 1 lb. per square inch, and must at the same time and under all conditions maintain an even and steady neutral flame. Our regulators are manfactured in our factory where none but the highest grade of material is used and the best of machinists and engineers are employed. These regulators are equipped with pressure indicators of high and low pressure, one to indicate the amount of unconsumed gas in the tank, and the other to indicate the working pressure of the gas at the torch.



Showing automatic oxygen regulator with indicator for medium pressure drum up to 500 lbs., also indicator for working pressure.

For high pressure drums regulator is exactly the same, but drum indicator shows pressure up to 3000 lbs.

On the low pressure 300 lbs., 100 foot oxygen drums, the 500 lb. gauge is used to indicate the amount of the unused oxygen in drum, and on the high pressure oxygen cylinders that carry a pressure when filled of 1800 to 2000 lbs., a 3000 lb. gauge is used for this purpose. The word "Vulcan" on any welding apparatus is your assurance of the highest quality.



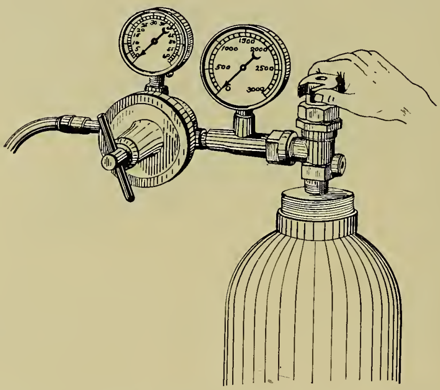
Automatic Acetylene regulator with indicator which insures steady working pressure and even flow of gas. Made of best materials and fully guaranteed.

How to use these regulators is shown with generator plants and compressed gas plants on pages 45 to 48 of Chapter 10.

CHAPTER X.

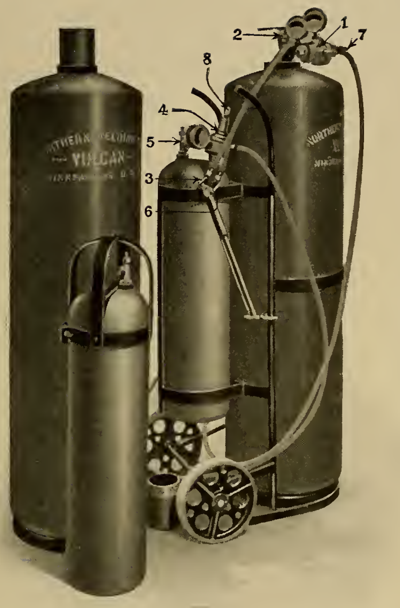
COMPRESSED GAS IN DRUMS.

From the first small plant which our factory produced until the present we have been very successful with plants having two drums of oxygen and two of acetylene, one for use and one for ex-



Valve on top of oxygen drum should be opened very slowly and left wide open while in use.

change of each gas. These plants are convenient for portable and stationary work. Gases are always ready, no time lost and while the acetylene gas costs more, for the man who does an ordinary amount of work these plants will probably always be desirable.

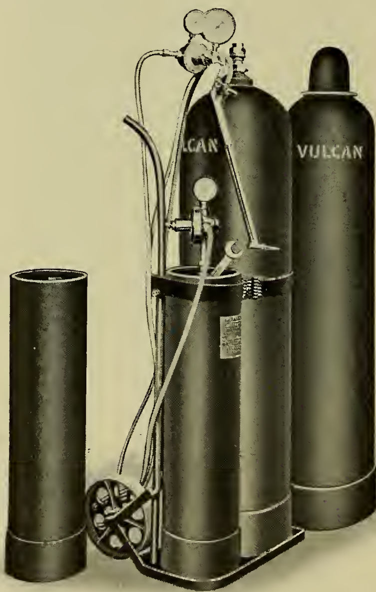


Vulcan No. 2 portable plant, showing low pressure oxygen drums.

Directions how to operate.

Connect oxygen regulator 1 to oxygen drum valve 2. Connect hose to regulator 1 and to torch valve 3. Connect acetylene regulator 4 to acetylene valve 5. Connect hose to regulator 4 and torch valve 6. Unscrew reg. valve stems 7 and 8 until they do not bear on the spring inside. This will close the regulator and prevent any passage of

gas when drum valves are opened. Now open drum valves 2 and 5 and torch valves 3 and 6. Screw down regulator valve stem 8 until gas flows from the torch tip and light gas. Continue to screw down stem until the flame is just on the point of leaving the end of the tip. Now screw down ox-



Showing high pressure oxygen drums containing 200 cu. ft. each. Weight of these 200 cu. ft. oxygen drums approximately same as low pressure 100 cu. ft. drums thus saving one half of freight expense. Cut also shows two 100 cu. ft. acetylene drums.

ygen regulator stem 7 and the flame will immediately become a brilliant white. More oxygen will shorten the brilliant flame and produce an outer bluish flame. The inner white flame will gradually become smaller as the oxygen is increased, until a small cone whose length is approximately three times its diameter is formed. Immediately upon obtaining this cone no more pressure should be given to the oxygen. This is called a neutral flame and should be maintained at all times when welding steel or cast iron. If an excess of oxygen or acetylene is used the metal is rapidly oxidized or carbonized, resulting in weak and brittle welds. In welding aluminum or brass the welding or inner cone may be made longer by an excess of acetylene as these metals do not readily absorb carbon. If the welding cone is short and stubby the pressure on both gases should be increased. If the flame blows away from the tip the pressure should be reduced. If the torch flashes back increase the pressure on both gases.

When operating acetylene generator instead of compressed gas in drums follow carefully directions in Chapter VII on generator and operate acetylene, oxygen and torch valves exactly the same, as in this outline, and where directions call for operating acetylene drum use generator in its place.

CHAPTER XI.

PREHEATING.

FIG. 10

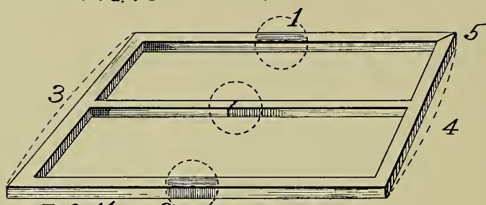


FIG. 11

1) Preheating when necessary of broken parts to be welded. 2) Adjusting of flame in blow torch so that operator uses the **neutral flame**, which means avoiding carbonization or oxidization of metal. 3) Annealing or cooling off slowly, after weld has been made, covering weld with lime, ashes or asbestos board so that weld cools about as slowly as when being heated and 4) finishing, practically covers with exception of boiler and a few other lines of work, the whole field of welding.

Let us state, first of all, that expansion and contraction cannot be overcome by force; the phenomena manifest itself, and it is perfectly useless to try to oppose it. The method is to avoid or limit its consequences.

Let us take a general example:—Here is a weld to be executed in the middle of a long bar (fig. 10). The dimensions are not important. No bad effects of expansion or contraction are to be feared when

it is free to expand or contract. No precautions are necessary to overcome the expansion and contraction in this case.

On the contrary, the same bar, having the same break, and in the same place, is now situated, for example, in the middle of a frame (fig. 11). What is now the position?

No bad effects of expansion need be feared, since, on heating to fusion the edges to be welded, the expansion takes place and the edges to be welded approach each other, the metal in fusion offering practically no resistance to this expansion.

But the weld is completed, and the metal commences to cool and contract. Now the bar which was free to expand does not offer the same freedom to contraction since the two extremities of the bar are fixed solidly to a frame which was not previously heated and consequently is unchanged.

If the metal is ductile, and elastic, the contraction of the parts heated will not produce a break, but simply a deformation or strain corresponding to the linear value of the contraction. This would often be the case, for example, with mild steel. If the piece was of cast iron, cooling would probably produce a break, probably in the welded portion.

A break will frequently occur in those metals which are ductile at ordinary temperatures but whose strength, when hot, is extremely low—copper, for example; it takes place during cooling in that part which remains at the highest temperature.

The realization of welds in such metals is possible. All that is required is reflection and adjustment.

One could raise the whole piece to a high temperature before welding, and thus produce expan-

sion in the entire mass, and in this way equal contraction. But, as a matter of fact, complete heating is not necessary. It is sufficient to heat, simultaneously with the operation of welding, the parts 1 and 2 of the frame and thus obtain equal expansion to that of the broken bar; then, on cooling, the contraction, is of equal importance in the case of the two parallel bars and the repaired bar. Therefore there is no strain in the metal or break.

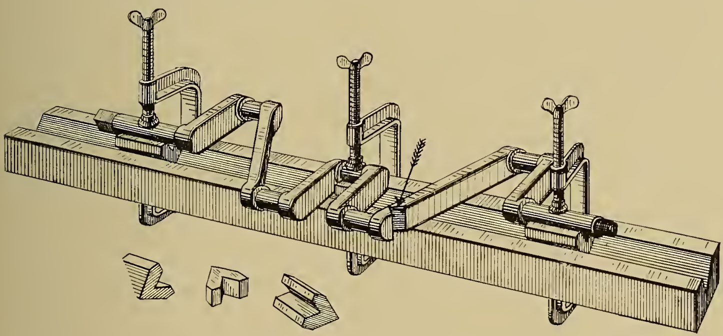
Suppose it were impossible to heat the frame at 1 and 2. Other methods are at the disposal of the welder; for example, a slight separation of the two bars 3 and 4 by bending separates the two edges to be welded. This done, proceed to weld, and at the end of the operation, that is to say, as soon as contraction commences, due to cooling, remove the keys, wedges, or screw jacks from between the sides 3 and 4. The return of the bent bars to their original position annuls the effect of contraction in the welded bar, and thus welded it should be free from strains, deformations, or breaks.

Another method is, although the success depends upon the thickness of the metal, to cut the frame at 5, execute the weld of the bar, and then weld at 5, the effects of contraction being least to be feared at this part. That is to say, sometimes we have to break a piece in order to repair it.

This example, taken from a hundred, shows the importance which the welder should attach to foreseeing the effects of expansion and contraction during the execution of the weld and on cooling. And this is evidently part of the "preparation of pieces," since it is not possible to guard against the consequences of these phenomena once the welding has commenced.

The devices to be followed vary in each case. We will study them in greater detail in the chapters devoted to each metal, but it is useful to emphasize that the phenomena of expansion and contraction are enemies of the welder; that in all welds means must be devised to prevent their effects and avoid their consequences by means of such methods as we have indicated.

It is very often not only more economical but absolutely essential to preheat the work before welding. It must be remembered that oxygen and acetylene gases are more expensive than most other



Showing position of crank shaft placed on "V" blocks ready for weld.

means of heating the work. Where it is desired to weld a large casting or forging, the speed of the operator can be greatly facilitated by heating the work in a common blacksmith forge, or in a rough brick oven built around the work, when charcoal is used. A common oil blow-torch can also often be used to advantage.

In most cases the principal reason for preheating is to overcome the effects of expansion and contraction. It is a well know fact that when metals are heated they expand, and when cooled, contract. Thus a steel bar twelve inches long at 100 degrees Fahrenheit will increase more than an eighth of an inch in length if heated to 2,100 degrees Fahrenheit.

As a common example, let us take a spoke of a fly wheel that has had a piece broken out of it. This piece just fits into its place. If this piece is welded in place without proper preheating, the expansion may be sufficient to crack the rim of the wheel, or when the spoke cools there will be sufficient contraction so that a break will occur in the weld or some other point. To overcome this expansion and resultant contraction in this instance, the broken part of the spoke should have been bevelled off, ready for welding, and then clamped in place. We should then have heated to a red heat the broken spoke, the adjacent spokes and the intervening rim. It is not necessary to bring every part to the same temperature, but seek to have it shade off. Otherwise, the preheating might produce stresses and strains too severe to be endured without breakage. Consequently, when the new material is filled in to make the joints, the spoke will be longer than needed at atmospheric temperature. It has, however, an opportunity for contraction, because it and the adjacent spokes are going back to normal size together, and when it is not too large, the entire casting should be preheated. All preheating of this character should be done slowly, so that the expansions will have time to distribute themselves. If the work is heavy the outside will heat before

the interior. When such conditions exist there is danger of having breaks. The remedy is to heat slowly, so that within and without the distribution of heat may proceed in a fairly uniform manner. A slow heating is especially to be advised where there is a combination of thin and heavy parts.

After the welding has been completed it is advisable to cover the work with sheet asbestos, so that it will cool gradually. This, for the same reason, is just as essential as slow and gradual heating. From the writer's experience, what is known

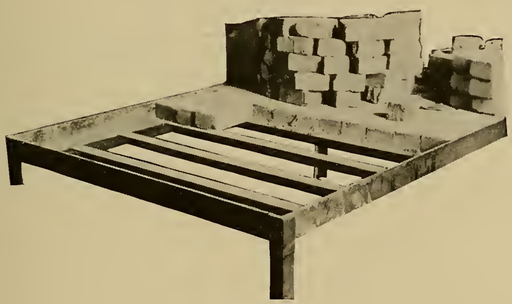


Illustration K.

as one-eight inch asbestos roll board is most suitable. Covering in dry, heated, slaked lime has also been found quite satisfactory.

Cuts K and L illustrate tables made of angle iron welded together. The top is covered with fire brick, on which suitable ovens of the desired shape can be built. Angle iron used is 2″ x 3″ for the ordinary sized table and the top of the oven is generally covered with heavy asbestos paper board to

confine the heat. After the charcoal fire or gases have brought the metal up to a point where it is slowly expanding, keep it covered until it is fully expanded when it will best respond to the welding flame. Cast iron and steel should be heated to a dull red before beginning to weld whenever a casting of these metals requires preheating.

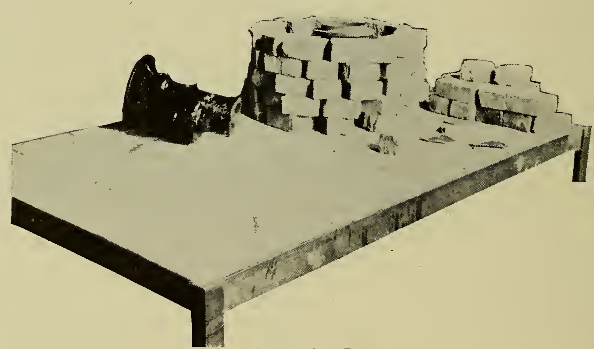


Illustration L.

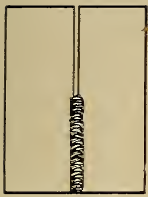


Figure 12.

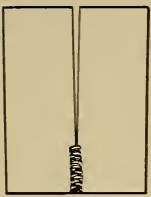


Figure 13.

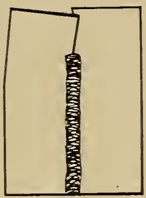


Figure 24.

The effect of expansion acts in such a manner that the edges to be joined separate and approach each other alternately.

If one wishes to join two plates by autogenons welding and the edges have been arranged parallel. when the weld has commenced one first observes a widening at the other end of the plates (fig. 13). If the welding is continued, the deviation quickly stops and the opposite movement is produced, that is to say, the edges approach each other (fig. 12(. On continuing the operation, expansion leads to the overlapping before the completion of the weld (fig. 14).

CHAPTER XII.

GENERAL WELDING INSTRUCTIONS.

CAST IRON WELDING.

In welding thin cast iron sections such as automobile cylinders. manifolds and the like. it is not necessary to chip out the piece where the fracture occurs as the flame will penetrate a thickness of ⅛ inch very easily and an inexperienced welder can almost invariably make a satisfactory job with-

out going to the trouble and expense of chipping out the crack. However if the piece is to be finished up or machined in any way it is better to chip out the fracture and introduce new metal in place of melting up the old, thus having new metal entirely to file or finish rather than the more impure metal of which the casting is made. It will be found much softer to work. In welding circular sections it is almost always necessary to chip out the crack or blow it out with the heat of the torch, this should be made into a "V" shape groove and then entirely filled with new metal from the filler rod. In welding any complicated castings always preheat them all over a dull red heat. This is always a safe rule to follow when in doubt as to preheating. After a welder has acquired considerable experience it is not always necessary to preheat the casting all over, and the more experienced a welder

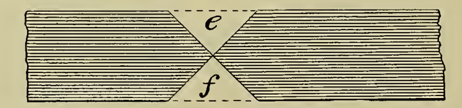
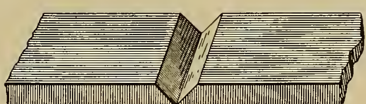
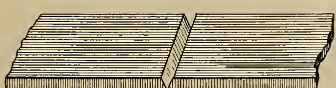


Illustration showing one-half saving in bevelling weld from both sides when possible; "E" "F" spaces being equal to "A" "B" spaces; and "C" and "D" extra spaces to be filled when bevelling from one side.

becomes the less preheating he will do in order to secure a good job. However a beginner should never be allowed to weld a complicated casting without preheating it as he will almost certainly fail. Hard spots in cast iron welding has been one of the most difficult points to overcome, even experienced welders have trouble in this manner. One of the causes for hard spots appearing is using too much flux or scaling powder. Scaling powder or flux should be used as sparingly as possible, using too little rather than too much, just enough should be used however to make the iron flow freely and to break up the scum on the surface. The cause for large areas of hard spots is the welding or the melting of metal on cold iron. If a heavy piece of cast iron is being welded and it is not hot enough it will chill the metal added, thus producing the hard spots, which is the same result as chilling castings. Car wheels are cast in iron chills, thus producing a very hard surface which is required on the periphery



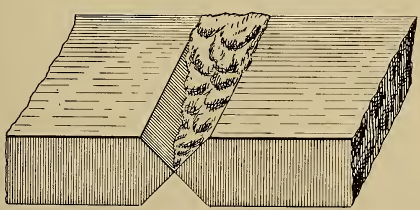


Bevelling of pieces from ⅛″ to $\frac{3}{16}$″ in thickness.
Bevelling for thickness in excess of ¼″.

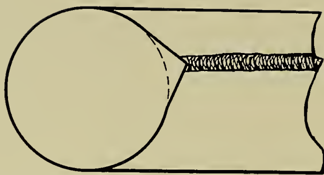
of the wheel. This same result is produced by melting metal on a cold piece of iron. Another puzzle to a great many welders is the appearance of a small round hard spot about an ⅛ to ¼ inch in diameter in an otherwise perfectly soft and good weld. This is caused in the following manner and it has taken a great deal of study to find out the exact reason for it. In welding a large casting the welder usually melts a small pool of metal and inserts the cast iron filler rod in it, gradually melting it all and filling up the fracture. Now if the cast iron filler rod is cold and it is inserted into this pool of moulten metal it will chill the metal surrounding it, producing the same results as if the hot metal was welded on a cold metal surface. It is almost impossible to get this spot soft again by melting it up, the metal filler rod should therefore be almost melting before it is inserted into the pool of moulten metal; however the metal filler rod should not be held away from the piece to be welded and metal melted off and dropped through the welding flame, as the welding flame is so intensely hot that it would burn the metal as it passed through the flame. The filler rod should always be in contact with the piece being welded but it should always be almost at the melting point.

Malleable casting has always been a source of trouble to welders since, in welding the metal is changed back to ordinary cast iron. Malleable castings are of course made of cast iron and then treated in ovens for several days which produces the malleability. In welding malleable castings the metal of course is melted and the carbon becomes evenly distributed again and the piece is converted back to ordinary cast iron; therefore

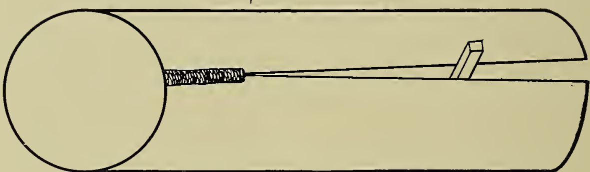
in order to weld malleable casting we must obtain some process by which the malleable piece need not be melted. This is accomplished in the following manner. Piece to be welded is ground out at the fracture so there is a groove at an angle of about 90 degrees, in fact this must be like a trough, the piece is then heated to a red heat, then sprinkled with bronze flux and it is necessary to see that the surfaces are clean and bright. When the pieces are at a dull red heat a small drop of Tobin bronze is melted off into the trough. If it lays in the trough in the shape of a small ball the casting is not yet hot enough but if it spreads out and adhers to the surfaces the piece is hot enough and the grooves should quickly be filled up. The piece should not be kept hot longer than necessary as the longer it is kept hot the more brittle it will become. An experienced welder can weld a malleable casting and the result will be practically as good as a new piece, in fact it will bend just as good if not better in the weld than it will at other places. It is also quicker to weld a piece of this sort than it is to weld a cast iron piece as the bronze can be flowed in very rapidly after the welding is once started, although



Bevelling and welding of thick pieces when practicable to work from both sides.



Results of welding a cylinder when the body has been previously tacked produce the deformation shown.

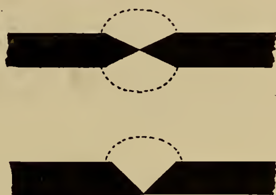


The proper method of welding steel cylinders, removing the wedge as the weld progresses.

the bronze filler rod is much more expensive than cast iron filler rod. In welding gear teeth and in welding cast iron vertically there is considerable difficulty experienced as cast iron will, upon welding, pretend to run away. This may be overcome a great deal by using graphite blocks cut and ground to shape to fit the piece being welded.

In foundries, in repairing defective castings, sand cores are made up and inserted in the defective castings and new metals melted on the sand core which acts as a support for the moulten metal. The sand cores may be then broken up and removed. In cases where a malleable casting cannot be ground out it may be reinforced with a small strip of steel, welding along each side of the steel after hav-

ing welded up the break, always demembering that the longer a malleable casting is heated the more brittle it will become until it is finally reduced to ordinary casting. In welding a strip of steel to a malleable casting, cast iron filler rod should be used although an experienced welder often uses a small steel wire.



Illustrations 20 and 21.

Illustrations 22 and 23.

Illustrations 24 and 25.

Illustrations 26 and 27. Nos. 20 to 27 Inclusive.

Illustrating the different methods in preparing joints for welding in sheet metal and boiler work.

STEEL.

In welding steel the beginner will almost invariably try to weld by getting it only red hot and then dropping a few drops of metal off of the filler rod onto the steel pieces and then trying to work it in to make a weld. This is entirely the wrong proceeding, the pieces to be welded should first be heated to a moulten state at the place to be welded, then the filler rod inserted in the moulten metal and the tip of the cone of the flame placed first on the steel pieces then on the end of the filler rod, gradually melting off the filler rod and filling up the cracks or the joint In the first place if the steel filler rod is melted off and the moulten metal allowed to drop through the flame the small drops

of metal become extensively heated and burned, while if the filler rod is in contact with the piece being welded the heat is conducted off to the larger piece and the metal remaining practically cool. Then again if the drops of moulten metal are allowed to drop on the steel for this welding it is very difficult to make a homogeneous joint, but if the steel is melting and the filler rod is put in the pool of moulten metal a good joint will be insured. It is always advisable to chip out the crack before starting to weld. After welding about three inches the metal should be heated on each side of the weld to a dull red heat until the weld is cold, then a slight tapping or pounding with the ball pein hammer on the heated part of the metal is advisable in order to stretch it as it cools, which helps to take care of the contraction; then continue to weld up three more inches and again heat the metal on each side of the weld. Proceed along this way until the entire weld is completed. Putting in a patch it is well to cut out the piece in a circular shape if possible putting in a new piece cut to fit and dish very slightly. Then after the weld is completed and the metal begins cooling the dished patch should be hammered in order to help take care of the contraction; this prevents the welded part from opening up. Many welders have better success by putting on a lap patch in place of a butt patch. In a large patch it is necessary to cut out the metal in back of the patch that is put on, otherwise the patch will be quickly burned through. Experienced welders weld cracks in boilers overhead as easily as on the side, but this requires time and experience to learn.

BRASS AND BRONZE.

In welding brass or bronze the pieces should be chipped out or ground out at the fracture the same as welding cast iron and then the groove should be filled in with manganese bronze; before filling in with manganese bronze the pieces should be well coated with bronze flux, which acts as a coating and keeps the oxygen of the air away from the metal, as this metal oxidizes very rapidly under intense heat. Copper, brass and bronze pieces require a larger tip than cast iron and steel pieces as the conductivity of this metal is much greater, copper especially requiring greater heat.

ALUMINUM WELDING.

While the melting point of aluminum is approximately 1,200 degrees Fahrenheit, or about half that of cast iron, it is much more difficult for the novice to weld satisfactorily. Cast aluminum is comparatively weak in a tensional direction, and it possesses a high rate of expansion and contraction. Its thermal conductivity is quite high, being comparable with that of copper. In welding aluminum its excessive expansion and contraction must constantly be kept in mind. On account of the low melting point of aluminum this expansion takes place very rapidly, and great care must be taken when preheating aluminum castings for welding. Care must also be exercised to see that the pre-heating temperature does not exceed 1,200 degres Fahrenheit, as any higher temperature will result in melting the entire casting.

Some writers advocate the use of a flux for welding aluminum. This is entirely unnecessary, and,

in fact, better welds can be made by an experienced "puddle" welder. By "puddle" welding of aluminum is meant that the aluminum is scraped off with a small steel rod flattened at one end, and additional aluminum from a welding rod is melted into the cracks. This additional aluminum is then worked or "puddled" by means of a steel rod, the oxy-acetylene flame being used to keep the metal in a sufficiently molten state to permit mixing the added metal thoroughly with the part being welded. As the fusion point of aluminum is very low, the operator must bear in mind that it is necessary to keep the working flame further away from the metal than is usually the case with cast iron or steel. It is also advisable to adjust the torch so as to furnish an excess of acetylene, as there is practically no danger of carbonizing the metal, since molten aluminum will not absorb carbon.

Aluminum solders:—The numerous alloys of the aluminum—copper-tin or copper-tin-bismuth type—which have been used for soldering aluminum at moderately low temperature, are all open to the same objection—that the soldered joint slowly loses its cohesion; i. e., its mechanical strength. This is due to the fact that aluminum, particularly in the presence of water, compares unfavorably with other metals on account of the "electrolytic local action," the aluminum becoming slowly decomposed.

The manufacturer of cheap welding apparatus cares little or nothing about the success of the user, being satisfied with a large profit on the first sale. The manufacturer of high grade welding apparatus, however, takes every reasonable precaution to see that the purchaser succeeds by providing personal

instruction, the usual charge being five dollars per day where the purchaser goes to the plant of the manufacturer. This charge is made to cover cost of gases, materials used, time of instruction, etc. Ten dollars per day and expenses is the usual charge where an instructor is sent out with the plant. In a few instances manufacturers provide the purchaser with personal instruction in their own works without extra charge. The advantages of this can readily be appreciated, as many valuable "shop kinks" can be picked up that cannot be shown in a book of instruction. In addition, free gases are furnished, and this alone is worth several dollars each day.

Another matter of importance is the use of the proper welding rod for the particular work in hand. The same thing may also be said of fluxes. There are several cheap, so-called fluxes on the market, but it is much safer to go to a reliable manufacturer of apparatus and get your supplies from him. Your extra initial expense will be more than justified by the increased certainty and quality of your success. It is very poor economy to do poor work rather than pay a reasonable price for high grade supplies.

MELTING POINT OF METALS.

	Centi-grade	Fahren-heit.
Tin	232	499
Bismuth	348	504
Lead	327	620
Zinc	478	787

Antimony	643	1,214
Aluminum	635	1,200
Magnesium	785	1,472
Bronze	908	1,692
Silver	940	1,751
Gold	1,072	1,747
Copper	1,082	1,943
Nickel	1,412	2,600
Cast Iron.		
White	1,100	2,075
Gray	1,200	2,228
Steel.		
Mild	1,375	2,532
Hard and Wrought Iron	1,600	2,737
Platinum	1,775	3,110
Iridium	1,950	3,542
Rhadium	2,000	3,632

CHAPTER XIII.

WELDING RODS AND FLUXES.

For welding ordinary wrought iron, steel plates, steel forgings and castings, the best results are obtained by using as the weld feeder the imported soft Swedish iron wire as free from carbon as possible. Some welding supply houses have special steel welding rods manufactured after their own formulas. These rods are somewhat higher priced, but the best results obtained from a good steel welding rod are well worth the extra cost.

For cast iron welding, specially prepared rods of cast iron, containing approximately 3% silicon, are employed. On account of the impurities in the ordinary cast iron casting, it is usually found advantageous to employ what is commonly known among welders as a "scaling powder," or cast iron welding flux. The purpose of this flux is to bring the impurities to the surface and prevent blow-holes. Pure aluminum rods of suitable size are used in welding aluminum.

Manganese and Tobin bronze are used quite extensively for welding brass, bronze and malleable castings, although, as a general rule, it has been found inadvisable to weld malleable casting subject to any great strain. The reason for this is that when the casting is heated to the point of fusion the metal is converted back to ordinary gray iron. Fair success, however, can be obtained by using a special bronze welding rod, and even ordinary copper wire has been found quite satisfactory.

Malleable iron, if thin and not varying too much in thickness, can be welded as previously outlined but when thickness varies considerable it requires the services of an experienced welder.

CHAPTER XIV.

METALS AND THEIR PROPERTIES.

STEEL.

Both mild and hard steels are alloys of iron and carbon. Carbon is united with iron in proportion of .05 (mild steel) per cent to 1.5 per cent (extra hard steel).

Increasing the carbon diminishes ductility and malleability of the alloy. Steel melts at 2532° to 2737° Fhr. The chief enemy of good steel welding is oxidation. Steel is generally conisdered the easiest of all metals to become expert in and yet because of ease and the good looks of the weld, welders are often deceived. The oxygen of the air rushes in on the metal bath. Combustion is going on rapidly and water vapor is frequently the result of it.

Water vapor is found with every welding flame but in less quantity with acetylene gas than other gases. Melting iron or steel invariably leaves a small coating of oxide of iron when blowpipe is used. Iron in molten state dissolves 1.1% of oxide. This oxide is frequently found in the mass of the weld. Frequent heating of parts around the weld so that cold air is excluded from the weld, annealing and hammering of weld making the texture of metal of much finer quality, all tends to produce the lasting and best weld.

CAST IRON.

Iron used for casting generally contains 3 to 4% of carbon. Hardness or brittle weld is the chief difficulty in welding cast iron. A small per cent of Silicon in the welding rod, slow cooling, absence

of manganese and avoiding sudden cool air chills when welding all help to produce the soft-weld which is necessary for finishing. A good flux will destroy the oxide or scales, and it also cleanses the metal to be welded and thus aids in the welding. Read the chapter on pre-heating, chapter 12, when getting posted on cast iron welds.

The field for autogenous welding of cast iron is very wide, in fact as various as the many kinds of castings; the foundry is every day finding new uses for this important work.

COPPER, BRASS AND BRONZES

are fully as successively welded with the blowpipe as are cast-iron and steel. Special welding rods are frequently of more use than fluxes with these metals. Pure copper with small per cent of phosphorus and aluminum is one of best rods to be used. Pre-heating is generally required with these metals. Hammering after welding is practical, after hammering reheat and then cool quickly.

Brasses being an alloy of copper and zinc, have under the blowpipe three distinct phenomena—namely, absorption of gases, volitization of zinc, and oxidation. Special welding rod and a cleaning flux are great helps in good work.

The welding rod should have a small per cent of aluminum in its makeup to deoxidize the weld.

Uniformity should mark the work of adding aluminum after casting. Borax is not a good flux for this metal. Sodium chloride, borax and boracic acid as used in red copper are found to be satisfactory.

Bronzes are alloys of copper and tin. Special welding rod and flux are essential for best welding. Avoid brass wire in welding bronzes. As in cast iron, bronzes are similarly treated and prepared using however, the special rods and fluxes as suggested.

GOLD, SILVER AND PLATINUM

all yield readily to the great heat of the oxy-acetylene flame. Gold melting at 1747° Fhr., silver about the same while platinum at 3110° Fhr., are frequently worked by this flame in a more successful way than any other known form.

CHAPTER XV.

BOILER WORK.

This is one of the most important branches of oxy-acetylene torch practice and unless the operator has become thoroughly proficient in the use of the torch he should not undertake this work.

It is difficult to lay down any set rules or instructions for boiler welding but the suggestions that follow may be of aid to the inexperienced.

The facility of execution in boiler work, as well as in practically all welding, depends in a large extent on the preparation of the parts to be joined. As is described elsewhere in these instructions, it is often advantageous to bevel the edges to be welded so as to facilitate the execution of the work and make sure of melting the metal throughout the entire thickness of the metal. This it is best to do when it is necessary to fit a patch in the side sheet or similar work. It is much easier for the operator however and it has been found more practical in welding on patches, to cut the patch to be welded on, large enough, so that it laps over the sheet on which it is to be welded. Before commencing to weld the patch on it should be dished sufficiently to take care of the contraction after the welding has been completed. As an illustration, suppose that the piece cut out of the sheet is 2 ft. x 3 ft. The patch should be large enough so that it will lap over at least one half inch all around making the total width and length of the patch one inch wider and longer than the hole in the sheet. Then if the patch is slightly dished and welded in place so that the convex side is toward the operator, it

can be heated for some distance around the center and hammered down while the weld around the outside is cooling and contracting. With a little experience the operator can easily determine how much a patch, of a given size, should be dished to take care of this contraction. It is also important in cutting the piece out of the side sheet that the hole is cut so that the edge of it will be as far away from the adjoining stay bolts as possible. The reason for this is that when the weld cools off, the resultant contraction will draw the metal away from around the stay bolts and cause leaks. Therefore the edge of the patch, where welded on to the sheet, should be at least an inch, or more if possible, from the adjoining stay bolts. If, however, a leak should be found around any of the stay bolts they can be welded to the sheet and additional metal should be added to reenforce the weld to take care of the strain caused by contraction when cooling.

Cracks in fire doors and mud rings can very easily be welded as these cracks usually occur in such a position that the contraction will almost always take care of itself without any great precaution. Every welder before attempting to make an actual repair on a boiler, such as putting on a patch, should spend considerable time practicing welding on odd pieces of steel plate of about the same thickness as boiler plate. These pieces should be placed in a perpendicualr position and welded together while in that position. Until the operator can make first class welds in practice he should, under no circumstances, attempt such important work as welding a patch in a side sheet or fire box.

Overhead welding should also be practiced as a great deal of this is necessary in boiler repairs. It

is of course always best to thoroughly clean the parts to be welded as rust, scale and dirt, when mixed with the molten metal, tend to weaken the weld to a considerable extent. Only the best grade soft, tough steel welding rods should be used. Three sixteenths and one quarter inch diameter rods are the most suitable sizes. Some dealers have rods made up for this special purpose, and when possible, these should be procured.

As previously stated it is difficult to lay down any set rules. Practice, experience and good judgment are, however, absolutely necessary, and this class of work should never be undertaken by the beginner.

The oxy-acetylene torch can be used very successful for re-tipping flues. By the old method flues and tips were scarfed; brought to a welding heat in the blacksmith forge and then welded by means of hammer blows. To do this work properly it would therefore require the services of an experienced blacksmith and in comparison to the new method takes considerable longer. While not absolutely necessary flues can best be retipped by means of the oxy-acetylene torch by first grinding or filing the ends of the flue and tip to a bevel edge, butting the beveled ends together and welding them in place. Care must be taken not to allow the metal to flow through and leave a rough edge on the in-inside. Should this occur, the end of the flue could be slipped over a piece of round shafting to be used as a mandrel, and hammered smooth. Very little extra metal should be added on the outside otherwise the flue would not pass through the flue sheet.

Where a pure supply of water is available, that

is where the water is not alkaline leaving lime deposits in the boiler, it has been found practicable to weld the flues directly to the flue sheets. When they are so welded, it is of course difficult to take them out and hence it is not recommended where it is necessary to frequently remove the flues on account of corrosion or lime deposits from alkaline water.

In welding new flues to the flue sheet, they should be welded on one end only, the other end being rolled. The welding should be done first leaving the other end free to take care of the expansion and contraction. The flue should be allowed to extend through the flue sheet about one-eighth inch or three-sixteenths inch and then welded around between the end of the flue and the sheet.

CHAPTER XVI.

CARBON DESTROYED IN CYLINDERS

Carbons deposits frequently form in the compression chamber of internal combustion engines. Excessive deposits cause knocking and loss of power. To remove this carbon by the old method of scraping takes a long time, especally when it is necessary to remove the cylinder to get at the carbon.

By means of the Vulcan oxygen carbon remover these deposits can be removed in but a small fraction of the time that is required by scraping.

DIRECTIONS FOR USING "VULCAN" CARBON BURNER.

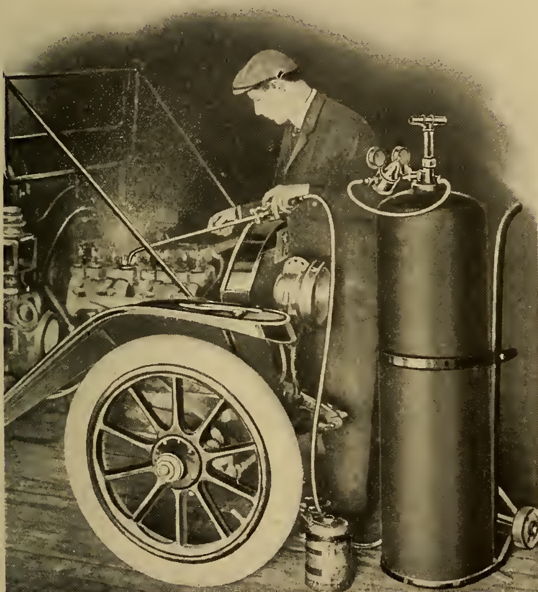
Remove spark plug and valve cap. Have piston at top of compression stroke and with piston at head of cylinder, position is right for practical work.

Inject in valve chamber and cylinder head, a small quantity, say one-half teaspoonful or so, of kerosene and after soaking carbon a minute or so light with a match or small torch and immediately insert "Vulcan" Burning Torch into valve chamber, press lever and allow a small quantity of "Vulcan" gas to mix with kerosene flame.

This, at first, will produce quite a flame coming out of opening and while kerosene is burning allow "Vulcan" gas to mix in chambers and soon instead of a clear flame will be carbon sparks coming out of opening, the gas eating all carbon deposit in cylinder walls, piston and valve heads, the

flame continuing until all carbon is removed down to the metal itself.

When torch is in chamber turn it into every part of opening so that there is not a spot left



Oxygen Carbon Burner at Work.

where gas has not had opportunity to meet the carbon.

"Vulcan" oxygen gas delights in eating carbon deposit in any form.

If kerosene flame goes out, put small quantity in chamber again and light over again.

This sometimes has to be repeated once or twice but once one has learned how, it's very short work to clean all parts thoroughly.

After first cylinder and parts are cleaned proceed to others same way.

In a very short time you will be able to do the four on an ordinary automobile in less than 20 minutes.

Keep face away from valve openings while cleanings as sometimes gases mix and unexpectedly flame out of opening with considerable noise.

This process does not over-heat cylinders at all; in fact, they are not as hot as in ordinary usage.

After cylinder is cleaned blow out loose carbon particles with compressed air.

A "Vulcan" Carbon Burning Tool and complete equipment will make money for the Garage as quickly as any other work that ever comes to the shop.

APPROXIMATE WEIGHT AND DIMENSION OF ACETYLENE GENERATORS.

Generator of Carbide	Height	Diameter	Weight	Crated	Crated size
25 lbs.	4 ft. 4 in.	20 in.	200 lbs.	290	30x28x 56 in.
50 "	5 ft. 6 in.	22 "	300 "	420	30x30x 68 "
100 "	6 ft. 6 in.	26 "	450 "	590	32x34x 80 "
200 "	8 ft. 2 in.	34 "	700 "	850	40x40x102 "
300 "	9 ft.	42 "	850 "	1000	48x48x112 "

WELDING PLANTS (Approximate)

No. 1	500 lbs.	
No. 2	600 "	
No. 3	650 "	Crated 740.
No. 3	840 "	Mounted on truck.
No. 4	750 "	Crated 875.
No. 6	950 "	Crated 1110.

WEIGHT OF OXYGEN GAS DRUMS.

Oxygen	Capacity	Pressure	Weight
Low pressure	100 cub. ft.	300 lbs.	150 lbs.
High Pressure	100 " "	1800 "	125 "
High Pressure	200 " "	1800 "	150 "

ACETYLENE GAS DRUMS 100 CUBIC FT., 150 TO 200 LBS., PRESSURE WEIGHT 80 LBS.

Oxy-Acetylene Cutting (Approximate)

Machine Cutting.

Tip	Thickness of Metal	Oxygen Heating Gas Pressure	Oxygen Pressure in Cutting	nches Per Minute
A	¼	4 lb.	10 b.	30
"	½	"	18 "	24
"	1	"	28 "	20
"	1½	5 lb.	30 "	16
"	2	"	36 "	12
B	3	"	40 "	9
"	6	6 lb.	60 "	4¾
"	9	"	90 "	3½

Hand Cutting.

Tip	Acetylene Gas Heating Jets Per Hour	Oxygen Gas Heating Jets Per Hour	Acetylene Presure
A	12.20	12.60	3 lb.
"	20	20.40	4 "
B	28.20	30.10	5 "

Cubic Feet Oxygen Used in Cutting Jets Per Hour.

5 lb.	10 lb.	20 lb.	30 lb.	40 lb.	50 lb.	75 lb.	90 lb.
32	41.50	71 to 75	90 to 140	110 to 200	120 to 220	210 to 300	35(

WEIGHTS OF GASES.

Oxygen:	at 20° C or 68° F	and 760 m/m	Pressure,	100 c. f.	weigh		8.29 lbs.
Hydrogen:	"	"	"	"	"		0.52 "
Acetylene:	"	"	"	"	"		6.74 "

VARIATION OF PRESSURES IN CYLINDERS WITH VARIATION OF TEMPERATURE; QUANTITY OF GAS REMAINING CONSTANT

Temperature	100 cu. ft. 300 lb. cyl. cyl.	200 cu. ft. 1800 lb. cyl.	150 cu. ft. 1650 lb. cyl.	100 cu. ft. 1800 lb. cyl
150°F	350 lbs.	2090 lbs.	1887 lbs.	2090 lbs.
100	320 "	1912 "	1750 "	1912 "
80	307 "	1844 "	1686 "	1844 "
68	300 "	1800 "	1650 "	1800 "
50	290 "	1736 "	1596 "	1736 "
32	278 "	1672 "	1539 "	1672 "
0	258 "	1558 "	1440 "	1558 "
-10	252 "	1522 "	1410 "	1522 "

QUANTITY OF GAS IN CYLINDERS UNDER VARIOUS PRESSURES; *TEMPERATURE CONSTANT.*

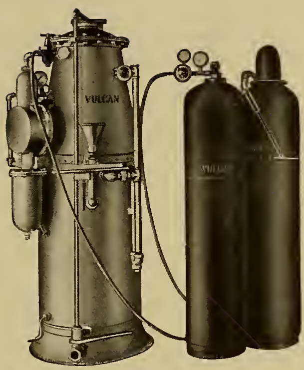
100 cu. ft. 1800 lbs.		200 cu. ft. 1800 lbs.		150 cu. ft. 1650 lbs.		100 cu. ft. 300 lbs	
Pressure	cu. ft. at 68°F	Pressure	cu. ft. at 68°F	Pressure	cu. ft. at 68°F	Pressure	cu. ft. at 68°F
1800 lbs.	100	1800 lbs.	200	1650 lbs.	150	300 lbs.	100
1620 "	90	1620 "	180	1100 "	100	270 "	90
1440 "	80	1440 "	160	990 "	90	240 "	80
1260 "	70	1260 "	140	880 "	80	210 "	70
1080 "	60	1080 "	120	770 "	70	180 "	60
900 "	50	900 "	100	660 "	60	150 "	50
700 "	39	700 "	78	550 "	50	120 "	40
500 "	28	500 "	56	700 "	64.5	100 "	33
300 "	17	300 "	34	500 "	45.5	75 "	25
100 "	6	100 "	12	300 "	27	50 "	17
18 "	1	18 "	6	100 "	9	25 "	8
9 "	½	9 "	1	11 "	1	3 "	1

Not corrected for variations from Boyle's Law

Consumption of Gases and Cost of Oxy-Acetylene Welding Approximate.

Tip	Acetylene Pressure	Oxygen Pressure	Thickness of Metal	Acetylene Consumption	Oxygen Consumption	Lineal ft. per hr.	Total cost With labor at 30c per hr.	Cost per lineal ft including labor at 30c per hr.
00	½ lb.	Used in lead burning in electric work and jewelry mfg.						
0	¾ "	Used in lead burning in electric work and jewelry mfg.						
1	1 "	1½	1/32	3 ft.	3.02	60	0.384	.0064
2	2 "	4	3/32	4.62	4.62	40	0.4288	.0107
3	2¾ "	5½	1/16	7.51	7.56	25	0.5112	.02
4	3¾ "	7½	1/8	11.42	11.51	18	0.62236	.0345
5	4½ "	9	3/16	16.10	16.42	10	0.7572	.0757
6	5½ "	11	1/4	23.01	23.38	7	0.95168	.1319
7	6½ "	14	5/16	30.12	31	5	1.1609	.232
8	6½ "	15	3/8	39.12	40.08	4	1.4145	.3536
9	6½ "	16	1/2	46.12	46.36	3	1.76	.88
10	6½ "	17	¾ & ⅝	55.40	56.45	2	2.32	.116
11	8 "	20	Heavy	78.20	80.15			
12	8 "	22	Extra heavy	102.12	105.20			
15	9 "	24						

Figures of cost are based on oxygen at 2c per ft. and acetylene at 8/10c per ft.



Complete "Vulcan" Acetylene Generator, oxy-acetylene welding and cutting plant.

Made in sizes from 25 lb. generator size up to 500 lb. with new 200 cub. ft. oxygen drums; freight on oxygas gas being less than half with old type drum.

A VULCAN

Welding Torch, Acetylene Generator, or Complete Welding Plant is far in advance of the average Welding apparatus. All special features are protected by patents. Cost is lowest consistent with greatest efficiency known.